STUDY GUIDE
CERTIFIED ENERGY MANAGERS EXAM
After March 1, 2005

The following is a list of the subjects for the CEM exam. Each subject covers a number of topics. Following the list of topics are suggested references with chapter numbers. The primary re ferences are the Handbook of Energy Engineering, by D. Paul Mehta and Albert Thumann, the Energy Management Handbook, 5th Edition by Wayne C. Turner, and Guide to Energy Management 4th or 5th Edition by Barney L. Capehart, Wayne C. Turner and William J. Kennedy. However, some other books are also referenced as appropriate.

The study guide will not lead you to answers to all of the questions, but it will certainly lead you to a large number of correct answers. A person with the necessary experience who reviews the study guide should not have any problem passing the exam. The exam has recently been modified (and the new exam will be used after March 1, 2005) and is similar in difficulty to CEM examinations from 2002 - 2004

The exam will be open book and will last four hours. All questions are 8 points each. The maximum exam score is 1,040 points and passing score is 704. All candidates must answer Sections I, II, and III: Codes and Standards and Indoor Air Quality, Energy Accounting and Economics, and Energy Audits and Instrumentation. The candidate should choose 8 of the remaining 14 sections. If more than 8 additional sections are marked, only the first 8 will be scored. After the first three mandatory sections, the fourteen sections remaining are as follows:

Electrical Systems	HVAC Systems
Industrial Systems	Motors and Drives
Building Envelope	Cogeneration and CHP Systems
Energy Procurement	Building Automation and Control Systems
Green Buildings, LEED and ENERGY STAR	
Thermal Energy Storage Systems	Lighting Systems
Boiler and Steam Systems	Maintenance and Commissioning
Alternative Financing	

STUDY GUIDE TOPICS & REFERNCES

I. CODES AND STANDARDS and INDOOR AIR QUALITY

CODES AND STANDARDS SUBJECT TOPICS

Federal Power Act
National Energy Act of 1978
Federal Energy Management and Improvement Act of 1988
Energy Policy Act of 1992
Natural Gas Policy Act of 1978
Public Utility Regulatory Policies Act of 1978
Federal Energy Regulatory Commission Orders 436, 500, 636, 636A, 888, and 889
ASHRAE/IESNA Standard 90.1-1999, 2001
IEC and IEEC Codes
ASHRAE Standard 90.2
ASHRAE Standard 62-1999, 2001
Model Energy Code
ASHRAE Standard 135-2001

Executive Order 12759, April 17, 1991, Federal Energy Management
Executive Order 12902, March 8, 1994, Energy Efficiency and Water Conservation at Federal Facilities
Executive Order 13123, June 3, 1999, Greening the Government Through Efficient Energy Management

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 1.
REF: Turner, Energy Management Handbook, Chapter 20.

INDOOR AIR QUALIY SUBJECT TOPICS

ASHRAE Standard 62- 2001
Acceptable Air Quality
Ventilation Rate Procedure
Alternate Air Quality Procedure
Typical Air Contaminants
VOCs and Bioaerosols
IAQ Problem Causes
CO2 Measurement and Control
Microbial Contamination

REF: ASHRAE 62 -2001 Standard
REF: Turner, Energy Management Handbook, 5th, Chapter 17

II. ENERGY ACCOUNTING AND ECONOMICS

SUBJECT TOPICS

Simple Payback Period
Time Value of Money
Present Worth
Net Present Value
Present Worth Method
After Tax Cash Flow Analysis
Internal Rate of Return
Energy Accounting
Point of Use Costs
Life Cycle Cost Method
Interest Formulas and Tables
Project Life
Annual Cost Method
Economic Performance Measures
Depreciation Methods
Impact of Fuel Escalation Rates
Btu Reporting
Efficiency Measures

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 2.
REF: Turner, Energy Management Handbook, Chapter 4.
REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 4.

III. ENERGY AUDITS AND INSTRUMENTATION

SUBJECT TOPICS

Role of Audits
Energy Management Measures
Combustion Analysis
Power Factor Correction
Very Basic Thermodynamics
Air Velocity Measurement
Light Level Measurement
Infrared Equipment
Fuel Choices
Energy Use Index
Audit Equipment
Load Factors
Combustion Analyzers
Electric Metering Equipment
Temperature Measurement
Pressure Measurement
Humidity Measurement
Energy and Power Measurement
HHV and LHV
Energy Cost Index

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 3.
REF: Turner, Energy Management Handbook, Chapter 3.

REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 2.

IV. ELECTRICAL SYSTEMS

SUBJECT TOPICS

Demand and Energy	Load Factors
Real Power	Reactive Power
Power Factor	Three Phase Systems
Power Factor Correction	Peak Demand Reduction
Rate Structure and Analysis	Motors and Motor Drives
Variable Speed Drives	Affinity Laws (Pump and Fan Laws)
Power Quality	Harmonics
Grounding	IEEE PQ Standard 519

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REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 4.
REF: Turner, Energy Management Handbook, Chapter 11.
REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 3.

V. HVAC SYSTEMS

SUBJECT TOPICS

Heating, Ventilating, and Air Conditioning (HVAC)

Affinity Laws	Performance Rating (COP, EER, kW/ton)
Psychrometric Chart	HVAC Economizers
HVAC Equipment Types	Air Distribution Systems (Reheat, Multizone, VAV)
Degree Days	Chillers
Heat Transfer	Energy Consumption Estimates
Vapor Compression Cycle	Absorption Cycle
Cooling Towers	Air and Water Based Heat Flow
ASHRAE Ventilation Standard	Demand Control Ventilation

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 7,8.
REF: Turner, Energy Management Handbook, Chapter 10.
REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 6.

VI. MOTORS AND DRIVES

SUBJECT TOPICS

AC Induction Motors	AC Synchronous Motors
DC Motors	High Efficiency Motors
Load Factor and Slip	Power Factor and Efficiency
Motor Speed Control	Variable Frequency Drives
Fan and Pump Laws	Variable Flow Systems
Motor Selection Criteria	New vs Rewound Motors
Motor Management Software	Power Factor Correction

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 4.
REF: Turner, Energy Management handbook, Chapter 11.
REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 12.

VII. INDUSTRIAL SYSTEMS

SUBJECT TOPICS

Waste Heat Recovery	Boilers and Thermal Systems
Industrial Energy Management	Fuel Choices
Steam Systems	Steam Tables
Heat Exchangers	Compressors
Turbines	Pumps
Compressed Air Systems	Air Compressors
Air Compressor Controls	Air Leaks

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 5, 6 & 15.
REF: Turner, Energy Management Handbook, Chapter 5,6 & 8.
REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 7.

VIII. BUILDING ENVELOPE

SUBJECT TOPICS

Thermal Resistance	Heat Transfer Coefficients
Insulation	Vapor Barriers
Solar Heat Gain	Solar Shading
Thermally Light Facilities	Thermally Heavy Facilities
Conduction Heat Loads	Psychrometric Chart
Air Heat Transfer	Water Heat Transfer

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 7.
REF: Turner, Energy Management Handbook, Chapter 9 & 15.
REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 6 & 11.

IX. COGENERATION AND CHP SYSTEMS

SUBJECT TOPICS

Topping Cycles	Bottoming Cycles
Combined Cycles	Fuel Selection
Prime Movers	Operating Strategies
Regulations	Codes and Standards
PURPA	Qualifying Facilities
Combined Heat and Power	Distributed Generation
HHV and LHV	Thermal Efficiencies

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 9.
REF: Turner, Energy Management Handbook, Chapter 7.

X. ENERGY PROCUREMENT

SUBJECT TOPICS

Natural Gas Policy Act	Energy Policy Act of 1992
Deregulated Natural Gas	Retail and Wholesale Wheeling
FERC Orders 888 and 889	Electric Deregulation
Utility Restructuring	Innovative Pricing
Marketers and Brokers	HHV and LHV
LDC, ISO, PX, EWG	Distributed Generation

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 1.
REF: Turner, Energy Management Handbook, Chapter 21, 23, & 24.

XI. BUILDING AUTOMATION AND CONTROL SYSTEMS

SUBJECT TOPICS

Energy Management Strategies	Terminology
Basic Controls	PID Controls
BACnet & LON	Signal Carriers
Power Line Carriers	Direct Digital Control
Distributed Control	Central Control
Optimization Controls	Reset Controls
Building Control Strategies	Communication Protocols
Expert Systems	Artificial Intelligence
Self-Tuning Control Loops	Energy Information Systems
TCP/IP	Internet, Intranets and WWW

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 4 and 10.
REF: Turner, Energy Management Handbook, Chapter 12.
REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 9.

XII. GREEN BUILDINGS, LEED, AND ENERGY STAR

SUBJECT TOPICS

Green Buildings	USGBC
Sustainable Design	LEED Certification
ASHRAE 90.1 Energy Cost Budget Method	
Certified, Silver, Gold, and Platinum	LEED NC
LEED CI	LEED CS
Water Efficiency	Energy and Atmosphere
Materials and Resources	Indoor Environmental Quality
ENERGY STAR Rating	Profile Manager

REF: United States Green Buildings Council, website with LEED presentations, www.usgbc.org
REF: ENERGY STAR presentation, ENERGY STAR website, www.energystar.gov.

XIII. THERMAL ENERGY STORAGE SYSTEMS

SUBJECT TOPICS

Design Strategies	Operating Strategies
Storage Media	Advantages and Limitations
Chilled Water Storage	Ice Storage
Sizing	Volume Requirements
Full Storage Systems	Partial Storage Systems

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 12.
REF: Turner, Energy Management Handbook, Chapter 19.

XIV. LIGHTING SYSTEMS

SUBJECT TOPICS

Light Sources
Lamp Life
Lumens
Zonal Cavity Design Method
Coefficient of Utilization
Lamp Lumen Depreciation
Dimming
Color Temperature
Visual Comfort Factor
Ballasts
Lighting Retrofits
Efficiency and Efficacy
Strike and Restrike
Footcandles
Inverse Square Law
Room Cavity Ratios
Light Loss Factors
Lighting Controls
Color Rendering Index
Reflectors
Ballast Factor
IES Lighting Standards

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 4.
REF: Turner, Energy Management Handbook, Chapter 13.
REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 5.

XV. BOILER AND STEAM SYSTEMS

SUBJECT TOPICS

Combustion Efficiency
Excess Air
Steam Traps
Condensate Return
Waste Heat Recovery
Scaling and Fouling
HHV and LHV
Air to Fuel Ratio
Boiler Economizers
Steam Leaks
Boiler Blowdown
Flash Steam
Turbulators
Condensing Boilers

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 6.
REF: Turner, Energy Management Handbook, Chapter 5 and 6.
REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 7 and 8.

XVI. MAINTENANCE AND COMMISSIONING

MAINTENANCE SUBJECT TOPICS

Combustion Control
Steam Leaks
Insulation
Group Relamping
Preventive Maintenance
Boiler Scale
Compressed Air Leaks
Steam Traps
Outside Air Ventilation
Scheduled Maintenance
Proactive Maintenance
Water Treatment

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 14.
REF: Turner, Energy Management Handbook, Chapter 14.
REF: Capehart, Turner and Kennedy, Guide to Energy Management, Chapter 10 and 11.

COMMISSIONING SUBJECT TOPICS

Purpose of Commissioning
Need for Commissioning
Retro-Commissioning
Measurement and Verification
Phases of Commissioning
Commissioning Documentation
Benefits of Commissioning
Commissioning New Buildings
Real Time and Continuous Commissioning
Commissioning Agent
Facility Design Intent

REF: Turner, Energy Management Handbook, 5th, Chapter 26

XVII. ALTERNATIVE FINANCING

SUBJECT TOPICS

Energy Service Companies
Utility Financing
Demand Side Management
Measurement and Verification Protocols
Risk Assessment
Loans, Stocks and Bonds
Energy Savings Performance Contracting
Shared Savings Contracts
Contracting and Leasing
Savings Determination
Energy Policy Act of 1992
Federal Facility Requirements

REF: Mehta and Thumann, Handbook of Energy Engineering, Chapter 16.
REF: Turner, Energy Management Handbook, Chapter 25.